Medicon Nutritional Health
Volume 1 Issue 2 July 2022
Review Article

Review of Nutritional Aspects for the Sustainable Development of Livestock Systems Based on Pastures and Tropical Forages

Raúl I Ruiz Pierrugues[1]* and Raúl V Guevara Viera[2]

[1]Research Center for the Animal Improvement of Tropical Livestock Avenue, 101 No.6214 between 100 and 62. Loma de Tierra, Cotorro, Havana, Cuba

[2]Faculty of Agricultural Sciences, University of Cuenca. Yanuncay Campus, Calle 12 de octubre and Diego de Tapia, Cuenca, Azuay

***Corresponding Author:** Raúl I Ruiz Pierrugues, Research Center for the Animal Improvement of Tropical Livestock Avenue, 101 No.6214 between 100 and 62. Loma de Tierra, Cotorro, Havana, Cuba.

Received: July 02, 2022; **Published:** July 10, 2022

Abstract

Nutritional aspects for sustainable development of livestock systems based on tropical pastures and fodders

Nutritional aspects of livestock production in concern to sustainable development is under review are reviewed. This represents a meaningful challenge to stockman, technicians, directors and researchers of the area. Application of sustainable animal production concepts and nutritional principles for milk and meat production mediate in the interpretation and management of biological factors that rule sustainable tropical livestock production. Emphasis is on potential and limits of tropical roughages and basic aspects of digestive physiology and metabolism of ruminants in order to increase its alimentary efficiency. This way converges to matching ruminant production systems with available resources and the placement for establishment adequate feeding systems. The goal is to design production systems based on grazing, trees and shrubs for forage, byproducts, farming crops and its residues, as adequate supplements and complements. Objectives will be diversify, integrate and alimentary self-sufficiency, based on scientific, economic, social and environmental elements. Tropical livestock sustainable production at farm level and its rural and environmental bounds, posse a decisive space where principles for nutrition, feeding, management of animals and plants, could increase productivity, stability, resilience and step up economic feasibility. A sustainable agriculture requirement goes to the development of human resources and not only enterprising and technical items. The importance of a rational use of natural and environment resources and an increase of human capability in order to an agricultural development with sustainable basis is irrecusably.

Keywords: ruminant nutrition; cattle; tropical sustainable development

Introduction

Sustainable vaccine production in the tropics at the farm level and in its rural and environmental environment, has a critical space where the application of principles related to nutrition, food and management of animals and plants, can increase productivity, stability and resilience and influence economic viability (Ruiz, 2017). The requirements for sustainable agriculture are essentially the development of human resources and not exclusively business and technological development.

It requires a rational use of natural resources and the environment and an increase in human capacities, which allow the development of agriculture on a sustainable basis. The sustainable development of tropical animal production is a challenge for producers, technicians, managers and researchers (Fernández-Baca, 1992).

In this area, updating the concepts of sustainable cattle ranching is indispensable (Becht, 1974; Altieri, 1995) to raise the level of knowledge, essential to increase the biological and technical-economic efficiency of cattle ranching (Aquino, 1999). This is based on the importance of applying nutritional principles to produce milk and meat and interpreting the biological factors that govern the sustainability of beef production in tropical conditions. (Preston and Leng, 1989; Escobar, 1990).

In this context, emphasis should be placed on the potential and limitations of tropical bulky foods and on basic aspects of the digestive physiology and metabolism of ruminants. (Bines, 1979; Chenost and Kayouli, 1997; Ruíz and Vázquez, 1983; Ruiz, 1984). This offers elements to manage the animal in interrelation with its diet and increase the efficiency of use of food resources. In this way, it will be possible to link animal production systems to available resources and provide guidelines for establishing adequate feeding systems. (Preston and Leng, 1989).

These procedures will make it possible to design production systems based on grazing, use of crops, crops, by-products and agricultural residues and integration of livestock/agriculture/forestry. The objectives of these projects are: diversification, integration and food self-sufficiency, based on scientific, economic, social and environmental principles, to achieve sustainable vaccine production in the tropics. (FAO, 1993; Ruíz et al., 2001; Reyes, 2001; Benavides, 2003; Martins et al., 2007; Funes Monzote, 2008).

The objective of the article is to review the main nutritional aspects for the sustainable development of livestock systems based on tropical pastures and forages. The regional technological context is considered as a challenge for producers, technicians, managers and researchers.

Sustainable Agriculture

There are multiple concepts and definitions of sustainable agriculture that exist today. (Delgado et al., 2002; Steinfeld, 2004). The consensus points out that sustainable systems have the challenge of meeting the growing needs of present generations, without compromising the possibilities of future ones, essentially in relation to the use of natural resources. (FAO, 1992; Delgado et al., 2002).

In this sense, the ancient Hindu sentence “we do not inherit the land from our parents, we borrow it from our children” is illustrative. Sustainable systems must satisfy seven fundamental aspects: 1/ Biological productivity. 2/ Economic viability. 3/ Stability over time. 4. /Resilience (flexibility, adaptation and recovery). 5/ Environmentally friendly. 6/ Social and gender equity. 7/ Cultural and religious acceptance.

Animal production. Role of ruminants

Existing animal production systems can be framed in:

1. Poultry on a large scale and at yard level.
2. Pig farming on a large scale and at a small level on integrated farms.
3. Intensive and dual-purpose dairy.
4. Integrated agricultural and livestock farms.
5. Extensive grazing and transhumant grazing systems.

These systems, in the first place, are producers of protein of animal origin, which play a decisive role in nutrition and human development. They act as transformers of foods of plant origin into others of high biological value for the human being.

The ruminant behaves efficiently with diets based on forage food resources, due to its ability to use vegetable fiber. However, in developed countries, 57% of cereals are devoted to animal consumption. (Leng and Preston, 2002). This situation indicates the unjustified competition between men and animals for the consumption of cereals (Pimentel, 2003).

Reid (1970) in analyzing the role of ruminants in the future, pointed out that cereals are more efficiently converted into meat by poultry and pigs than by ruminants. In this analysis, the dairy cow may be more efficient in the production of protein for human consumption than the laying hen, even at average levels of milk production (3600 kg/lactation).

The production of beef is little favored in relation to the protein or energy available for human consumption from the digestible energy supplied to the animal. However, the nutritional needs for meat production are simpler than for milk production, both in terms of nutrient diversity and quantities. (Preston and Leng, 1989).

In addition, in the production of beef, it is possible to use agricultural and industrial by-products and residues of a fibrous nature, non-protein nitrogen (NNP), grazing in marginal non-arable areas (rugged, coastal, and difficult to access) and low-cost resources that do not compete with man or other animals in food or arable land (Ruíz, 2002; Ruíz and Álvarez, 2007).

Sustainable vaccine production in the tropics

Cattle production in grazing is the predominant system in Latin America and the most economical way to feed medium or low production herds for the production of milk, meat and breeding cattle (Pérez-Infante, 1977; Pezo, et al., 1992). In this context, the Sustainable Systems of Low External Inputs (LEISA) have been developed, which is discussed in several sources (LEISA magazines, 2017). These systems can increase their efficiency with the introduction of improved pastures, to evolve towards dual-purpose systems or by integrating with agricultural and forestry activities what is conceptually called Agroforestry (Funes-Monzote, 2008; EEPF Indio Hatuey, 2016). Although in specialized dairy systems, it is more feasible to apply a greater degree of intensification. (Mc. Meekan, 1965; Martins et al., 2007; Ruiz, 2011).

The understanding and possible transformation of production systems and dairy agribusiness requires the analysis of their internal and external environments, which show their complexity, due to the multiple factors involved. (Ruiz et al., 1999). In the study of these factors, the farm is considered the core of the internal environment where the interactions and interrelations between the soil, plants and animals are manifested, under the direction of man. It is affected by: labor, milking and milk quality, reproduction, equipment and implements and animal health. In the external environment intervene: government policies, processing industries, intermediaries, suppliers and the domestic and foreign market.

Sustainable vaccine production in the tropics implies the expression of the concepts presented on sustainable agriculture, animal production systems and the productive particularities of cattle in the environment of the complexities of production systems. (Ruíz and Álvarez, 1997; Martins et al., 2007). The components are:

1. Organic nutrition.
2. Rational feeding.

- Management and management of human, natural, material and financial resources

In the analysis of the components: Ecological Nutrition and Rational Feeding, it is necessary to address the nutritional principles based on updated knowledge on the biochemical and physiological concepts that govern the nutrition of ruminants, applied to zootechnical practice (Ruíz, 1984; Preston and Leng, 1989). In addition, the basic elements for a rational management of grazing, within the multiple interactions of the soil-plant-animal-man relationship, center of the cattle system.

Tropical food resources

The complexities of nutritional management of ruminants fed with tropical food resources to achieve sustainable milk and meat productions, requires knowing and rationally applying the scientific principles of ruminant nutrition enunciated in this article.

In tropical areas these bases have been studied and reviewed in recent years in animals fed with the various existing resources, in topics related to the digestion and metabolism of the rumen and intermediate of the animal (Preston and Leng, 1989). The resources for feeding ruminants can be classified into:

1. Fibrous: native, naturalized or improved pastures, agricultural and industrial residues and by-products.
2. Non-fibrous: protein meal of plant and animal origin, grains, mineral salts, sources of NNP, agricultural and industrial residues and by-products.

Tropical grasses are the main food for more than 3 billion cattle, small ruminants and other herbivores, a fundamental source of protein for the population of a large number of countries. (Pérez-Infante, 1977; Minson, 1990; Pezo et al., 1992). Ecological factors, pasture structure, management methods and soil and seasonal variations are determinants in the quality and productive possibilities of this forage germplasm (Minson and Mc. Leod, 1970; Stobbs, 1976; PérezInfante, 1989; Paretas, 1990). The main limitations noted for tropical grasses are:

1. Low energy availability (high fiber and low digestibility).
2. Deficiencies of essential nutrients (mainly nitrogen and phosphorus).
3. Nutrient imbalance (low glycogenic energy).
4. Low consumption.

Voluntary consumption

The productivity of grazing ruminants is mainly limited by the amount of food they can voluntarily consume and the efficiencies of digestion and metabolism (Arnold, 1970). For this reason, the conversion of grass nutrients into edibles by man will depend on the magnitude of voluntary consumption and its limitations will reduce the overall efficiency of food processing into animal products, essential elements for bovine sustainability (Reid, 1970).

The regulation of appetite by the animal is carried out by integrating the stimuli in the Central Nervous System (CNS), converted into signals that trigger the receptors and specific detection systems (Anand and Brobeck, 1953). The signals, of a metabolic or sensory order, will act in coordination through a complex system of nervous nature, with a substructure of reflexes, facilitated or inhibited by centers in the brain (Brobeck, 1957), located in two areas of the hypothalamus:

1. Middle ventral hypothalamus, Satiety Center.
2. Lateral hypothalamus, Hunger Center and separately, the Rumination Center.

The factors involved in the regulation of voluntary consumption inherent to the animal (intrinsic), are linked to the digestion and capacity of the digestive tract (physical factors) or on the other hand, to the use of the products of digestion (metabolic factors) (Baumgardt, 1970; Bines, 1979). This implies the relationship with the digestibility of the food in the first case (Conrad et al., 1964) or with the energy density of the ration in the metabolic causes (Baumgardt, 1970).

Voluntary consumption of the ruminant is limited by physical factors when the feed has a dry matter digestibility of less than 65% (Conrad et al., 1964) or a digestible energy concentration below 10.8 MJ/kg MS (Baumgardt 1970).

In this range are tropical grasses and forages determined largely by their fibrous tenor, capacity of the reticulum-rumen (fibrous ballast) and time of stay of the food in the rumen (retention time), inverse of the speed of passage. The digestive content will be reduced by rupture, absorption and by the passage of the remaining fractions to the back parts of the digestive tract. In this process, the content of cell walls and lignin in the forage, rumination and the rate of passage, for the evacuation of the organ, are the factors that dominate the physical regulation of voluntary consumption of fodder.

The filling of the digestive tract, by rumin-abdominal distension, acts as a regulatory signal that once integrated by the hypothalamus, will determine the amount of fibrous ballast that can be retained. This fibrous ballast will depend on the live weight and physiological state of the animal (Ruíz and Menchaca, 1990) and by varying the physiological state of the animal and its nutritional requirements, consumption would adjust to the new needs (Baumgardt, 1970).

The potential dry matter consumption could be estimated from the capacity of the animal's fibrous ballast (age, weight, physiological state) and the fibrous tenor of the forage resource. (Ruíz and Menchaca, 1990). The voluntary consumption of fodder is the most precise criterion of their nutritional value, as it is a measure of the rate of digestion of cellulose, dependent on the lignification of the plant (Minson, 1990). The constituents of the plant cell wall (cellulose, hemicellulose, lignin, lignified nitrogen compounds and fiber-bound protein) limit consumption when they exceed 60% of the MS of forage (Conrad et al., 1964), which happens in most tropical grasses, by occupying a space in the rumen for a longer time than the most rapidly digestible fractions (Thornton and Minson, 1972).

Among the factors not determined by the animal (extrinsic) are considered those related to the grass and its chemical-structural characteristics and to the external environment in its climatic consequences, where other factors related to man or the environment are added, without climatic implications. (Ruíz and Vázquez, 1983). In tropical legumes, the available evidence shows a different situation, since despite having a similar amount of lignin as grasses, they are digested more quickly and remain less time in the rumen (Thornton and Minson, 1973). These authors have suggested that the higher packing density of legumes in the rumen conditions a shorter retention time in the organ and greater consumption.

Consumption of tropical food resources decreases when the mineral content of the plant is below minimum acceptable levels. For nitrogen this occurs when its level is less than 1% of the MS of the forage, where its deficiency creates a primary lack of ammonia for the microorganisms of the rumen, which affects their activity and consequently consumption. (Leng, 1990). Although more recent results support the concept that degradable protein in the rumen is the main constraint for microbial protein production in tropical grasses, where rumen filling is lower in natural grasses, related to low nitrogen levels in rumen and plasma content. (Panjaitanet al., 2010). This is common in systems of low external inputs, based on natural or naturalized grasses, without fertilization, little investment in rotation of paddocks and complementation, no supplementation. (Ruiz, 2010; 2011) or in rations based on sugarcane fodder without adequate supplementation and supplementation (Ruíz, 2012).

Grazing

Grazing is the harmonious and mutually beneficial encounter between the animal and the grass, where the rational management of the pasture is synonymous with good management (Voisin, 1963), based on the characteristics of the pasture (Voisin, 1963) and the needs of the animal together with the priority protection of the soil. (Voisin, 1964). From the above principles, the maximum consumption and production will be obtained by linking, the best animal, to the ideal grass at the right time, from the following elements:

1. Use the grass at the optimal time and according to the animal requirement.
2. Graze in the best times and environmental conditions of the day.
3. Supplement according to the balance of nutrients that the animal requires.

Ruíz and Vázquez (1983) point out that, in grazing, there are interrelations between the plant and the animal, which can quantitatively alter the order and importance of some factors of variation, where the main ones that govern the consumption of the animal in grazing are:

4. Availability and accessibility of sheets.
5. Selection possibilities.
6. Consumption speed.
7. Bite size.

8. Digestion rate.
9. Rumen evacuation.
10. Supplementation.
11. Effects of the climatic environment.
- Other biotic and abiotic effects.

The grazing animal performs a general meal, on a horizontal plane and a specific or selective meal on a vertical plane, which is the result of instinct and experience. (Jensen, 2004). The ingestion component of animal grazing behavior, consisting of: search, grasping, shallow chewing and swallowing, is oriented to the defoliation of the upper and denser strata of the lawn (Stobbs, 1976). For this reason, the herb selected by ruminants has a higher content of protein and other digestible nutrients and a lower level of fiber than the whole plant. (Stobbs, 1973a; Ruiz et al., 1981).

In all cases the leaves are more nutritious than the green or dry stems which are ingested in smaller amounts, rejecting the senescent material. (Minson and Laredo, 1972), for a longer retention time in the rumen (Laredo and Minson, 1973). Consequently, voluntary consumption and nutritional value will be affected by the number of species available and by the selection made by the animal. The relationship of the plant complex with the animal complex, during grazing, makes evident the impossibility of understanding one, without understanding the other. (Stobbs, 1975; Ruíz and Vázquez, 1983).

Stobbs (1976) points out that dry matter consumption can be increased by producing a high-density lawn with low stem content and high leaf-to-height ratio, through leafy grass selection, fertilization, and grazing management.

In the animal complex it is necessary to answer What does an animal eat that grazes? How much can you eat? What factors govern selection? The grazing ruminant has a wide range of potential food, in the form of plant species, with green or mature leaves, stems, seeds and inflorescences. The physical, chemical and nutritional characteristics are particular and also with different densities and physical apibilities, where the animal exercises a high degree of selection, depending on the level of available and accessible leaves. If these are restricted, the selectivity will be low and the opposite when the availability increases, then the selectivity will depend on the level of satisfaction of the requirements and the rumen filling.

Stobbs (1975) noted that, under grazing conditions, voluntary consumption (C) is a function of the time spent harvesting the feed (T) and the rate of harvest, which breaks down into chewing rate (M) and bite size (B), where: $C = T \times M \times B$. In the different grazing conditions, the animals will try to cover their requirements, the grazing time (T) will be short when there is abundance and quality in the pasture, with a maximum of 9 hours. In abundant but mature pastures, grazing time is extended to 11 hours and between 7 and 8 hours in young pastures of temperate countries (Voisin, 1957). The limits of fatigue of the animal are reached when grazing around 12 hours, although in conditions of extreme scarcity, they can reach 13 hours of grazing (Stobbs, 1977).

The rate of consumption or chewing (M) indicates how easily the animal harvests the grass. Tender pastures show a decrease in the rate of chewing at the end of grazing, due to the greater ease of harvesting and the nutritional requirements of the animal are met more quickly (Stobbs, 1977). The most important component of grazing behavior with respect to consumption is bite size (B), expressed in g/bite. This directly influences the grazing time (T) and the rate of consumption or chewing (M). When B is small, less than 0.3 g of MO/bite, the animal needs more bites in the same time, or more likely, will have to increase T to consume the required grass. (Stobbs, 1973).

The bite size for young tropical grasses averages 0.34 g of MO/bite, reducing to 0.17 in mature grasses against 0.43 g of MO/bite in temperate grasses. (Stobbs, 1973). There are variations by type, category and breed of the animal and above all by the characteristics of the pasture: leaf yield, age of regrowth, density, accessibility and its vertical distribution. (Stobbs, 1973). The available and accessible leaves are the individual factor of greatest influence, manifesting itself in the decrease in the size of the bite, with the time of occupation of the quart, as the selective defoliation carried out by the animal is difficult. Similarly, the age of regrowth and grass species interact for an optimal bite size (Stobbs, 1973).

The dairy cow makes two large daily meals, which coincide with the sunrise and sunset, cool and pleasant hours (Voisin, 1957). The time and daily distribution of grazing is also influenced by solar radiation and temperature, in the tropics about 50% is nocturnal and the rest at the coolest times of the day (West, 2003). The existence of trees in the grassland favors day grazing, since the animals take advantage of the shade and comfort produced by the trees to graze (Murgueitio et al., 2006).

The energy costs when harvesting the grass increase as grazing time increases. Low-quality grasslands, very large quarts, long distances between grazing areas and milking and troughing grounds, increase energy expenditure and reduce the energy available for production. This aspect can be aggravated in areas of undulating relief or rugged topography (Stobbs, 1977).

Quantitative information on the consumption of grazing animals in the tropics is scarce, more pronounced if we refer to lactating cows (Vicente-Chandler (1976) estimated dry base consumption of 3.0% of live weight, for lactations of 4 800 kg in 305 days. Pérez Infante (1986) in numerous experimental trials with Holstein cows in pastures with 400 kg of N/ha/year and irrigation, estimated dry base consumption between 2.6 and 2.8% of the live weight.

Ruiz et al. (1981), in lactating cows in intensive grazing of cross-bermuda-1 (C.*dactylonvc. coast-cross*) fertilized and irrigated with high quality with or without supplementation with concentrate, calculated in the animals of both treatments similar dry matter consumptions, higher or very close on a dry basis at 3% of the live weight and 150 g/kg PV $^{0.75}$ /day. These figures allowed them to calculate that the animals consumed 11.64 kg of leaves/day and used 93.9% of the available leaves and 3.80 kg of stems, 95.3% of those available. The green material in its entirety (leaves + stems) was used at 95.3% and the stems at 21.3%, the senescent material was only used at 11.9%.

This clearly shows the selection pattern of the animal when using a tropical grassland with high quality. (Ruiz et al., 1981). The use of upper strata (above 20 cm) of this tropical grass, close to 94%, is similar to that obtained with temperate pastures. This information suggests that in a good tropical grass with a management of the animal that allows its encounter with an ideal lawn, the upper strata can be comparable in quality and use to the grasses of temperate countries and obtain high milk productions.

The corollary is that the rational management of grazing, applying the nutritional principles exposed and with the appropriate methods and techniques, must offer an ideal pasture: dense, few stems and abundant leaves in the upper strata of the lawn, to achieve adequate milk productions.

In tropical countries the concept of use must be handled differently, given by the heterogeneity of the lawn and the consequent patterns of selection of the grazing animal. In temperate countries it is considered that there are no increases in consumption or animal production when more than 20 kg MS/cow/day is offered. However, in tropical conditions when the availability of grass is less than 30 kg of MS of green material, milk production declines rapidly (Stobbs, 1975).

In these conditions the animal has difficulty obtaining the optimal bite size and achieving maximum grass consumption (Stobbs, 1973). Although high yields make it equally difficult to harvest feed, insufficiency in one case and inaccessibility in another, they can restrict grass consumption in young or late stages of growth, although there is an optimal state of regrowth for each grass species (Stobbs, 1973).

In tropical grasslands to increase milk production, the total use should not be high, since a corresponding availability of a hojoso material accessible to the animal must be maintained. In different tests carried out in Cuba with lactating cows in grazing, the average total utilization fluctuates from 40 to 60%, when good results are obtained (Martínez, 1978; Martínez et al., 1980; Pérez Infante, 1986).

Final considerations

The first application of knowledge to human development that marked an era was the Revolution of Agriculture in the seventeenth and eighteenth centuries, achieving an activity established and capable of organizing society on it. At present knowledge continues to be applied to the earth, instruments, products, but above all it is applied to knowledge itself, because human resources are located as the beginning, middle and end of changes. From the economic point of view, human resources acquire great relevance, since they become the essential productive factor of competitiveness and of the society of the future.

The knowledge society, of the general and integral culture, based on qualified human resources, categorizes countries by their creative work capital, with prioritized work spaces for symbolic analysts, capable of generating and transferring knowledge to specific economic activities, such as agriculture. With knowledge as a central element, education represents the cornerstone of the competitiveness of companies, economies and societies, where education and cooperation are democratic and leveling factors.

Education, training and information can qualitatively transform agriculture. The requirements for sustainable agriculture are essentially the development of human resources and not exclusively business and technological development. It requires a rational use of natural resources and the environment and an increase in human capacities, which allow the development of agriculture on a sustainable basis.

Thanks

The authors appreciate the information provided by different researchers from Latin America and other continents, by sending scientific articles and also to the people who work in the libraries visited by Research Institutes and Universities in face-to-face and virtual mode to collect the information relevant to the work.

Conflict of interest

There were no conflicts of interest between the authors who wrote this review article, nor with the authors who provided information to supplement the article.

References

1. Aquino CE. "Challenges and opportunities of agriculture in the Americas, beginningthe 21st century". Memoirs IV Ibero-American Forum on Agriculture. Ministry of Agriculture, City of Havana, Cuba (1999).
2. Altieri M. "Agroecology. The Science of Sustainable Agriculture". West-View Press, Boulder (1995).
3. Anand BK and Brobeck JR. "Hypothalamic control of feed intake in rats and cats". Yale. Biol. Med 24.2 (1951): 123-140.
4. Arnold GW. "Regulation of Food Intake in Grazing Ruminants". In Physiology of Digestion and Metabolism in the Ruminant (Ed. A. T. Phillipson). Oriel Press, Newcastle upon Tyne (1970).
5. Baumgardt BR. "Control of feed intake and energy balance". In Physiology of Digestion and Metabolism in the Ruminant (Ed. A. T. Phillipson). Oriel Press, Newcastle upon Tyne (1970).
6. Becht G. "Systems Theory: The Key to Holism and Reductionism". Bioscience 24.10 (1974): 59.
7. Benavides J. "Forage Trees and Shrubs: An alternative for sustainability in livestock farming". International Course Livestock, Sustainable Development and Environment. Memoirs of the Workshop. Pasture and Forage Research Institute, Ministry of Agriculture. Havana, Cuba (2003): 157-174.
8. Bines JA. Voluntary food intake. In Feeding Strategies for the High Yielding Dairy Cow (Eds. W H Broster and H Swan) Granada Publishing, London. UK (1979).
9. Brobeck JR. "Neural control of hunger, appetite, and satiety". Yale. Biol. Med. DEER 29 (1999). (1957): 5.
10. Chenost M and Kayouli C. "Roughage utilization in warm climates". Animal Production and Health. FAO, Rome 135 (1997).
11. Conrad HR, Pratt AD and Hibbs JW. "Regulation of food intake in dairy cows. I. Change in importance of physical and physiological factors with increasing digestibility". J. Dairy Sci 47 (1964): 5.
12. Thin CL, Rosegrant MW and Meijer S. Livestock to 2020. The Revolution Continues. In World Brahman Congress, Rockhampton,

Australia (2002).

13. Escobar A. "Noveltiesin the dairy cattle feeding systems in Latin America and the Caribbean. Expert Consultation on Cattle Feeding for Sustainable Dairy Production. Item 6. FAO, Kingston, Jamaica (1990).
14. Pastures and Forage Experimental Station (EEPF) Indian Hatuey. Multipurpose treesin livestock forestrysystems. Great Indian EEPF Publisher. Matanzas, Cuba (2016): 52.
15. FAO. World Food Security Committee. Criteria for monitoring food access and family food security. Rome (1992).
16. FAO. The diversity of nature: a valuable heritage. World Food Day. FAO, Rome, Italy (1993).
17. Fernandez-Baca S. "Advances in milk and meat production in the American Tropics". FAO Santiago de Chile, Chile (1992).
18. Funes-Star F. "Farming like we´re here to stay. The mixed farming alternative for Cuba". Ph.D Thesis Wageningen University. The Netherlands (2008): 211.
19. Guevara R, Ruiz R and Garcia-Vila R. "GrazingRational Voisin for Sustainable Bovine Production". Monograph. Information Management Center. University of Camagüey, Cuba (2003).
20. FEED. Low external input systems of Agriculture (2017).
21. Leng RA. "Factors affecting the utilization of poor quality forages by ruminant animals particularly under tropical conditions". Nutrition Research Reviews 3.1 (1990): 277-303.
22. Leng RA and Preston TR. "General diagnosis and trends in relationships with livestock production and environment". Livestock Research for Rural Development 14 (2002): 5.
23. Martinez RO. "Rationalization of the use of the concentrates for dairy production vacanagrazing". Doctoral Thesis in Veterinary Sciences Institute of Animal Science, Havana, Cuba (1978).
24. Martinez RO, Ruiz R and Herrera RS. Milk production with cowspasturebermudacross 1 (Cynodondactylon). 1. Different levels of supplementation with concentrates. Rev. Fr. Cuban Scienc. sour 14 (1980): 2.
25. Martins., et al. "Knowledge and technological strategies for milk production inregionestropics. EMBRAPA Gado of Leite. Judge of Fora, MG (2007): 472.
26. Mc Meekan CP. From grass to milk. Southern Hemisphere Publishing, Montevideo. Uruguay (1965).
27. Minson D. Forage in Ruminant Nutrition (1972).
28. Minson D. Voluntary intake, digestibility and retention time by sheep (1973).
29. Minson DJ. "Forage in ruminant nutrition". Academic Press. New York. DEER (1990).
30. Minson DJ and McLeod MV. "The digestibility of temperate and tropical grasses". Proc. XI Int. Grassld. Congr., Queensland (1970): 719.
31. Murgueitio E., et al. Adoption of livestock agroforestry systems. IV Latin American Congress of Agroforestry for Sustainable Livestock Production. Matanzas, Cuba (2006).
32. Panjaitan T., et al. "Intake, retention time in the rumen and microbial protein production of Bos indicus steers consuming grasses varying in crude protein content". Animal Production Science 50 (2010): 444-448.
33. Paretas JJ. "Ecosystems and Regionalization of Pastures in Cuba". Pasture and Forage Research Institute. Havana, Cuba (1990): 133.
34. Perez-Infante F. "Some factors that affect the production of grazing dairy cows". Thesis Doctor in Veterinary Sciences. Institute of Animal Science. Havana Cuba (1986).
35. Pezo D, Romero F and Ibrahim M. "Production, management and utilization of tropical pastures for milk and meat production". In: Advances in the production of milk and meat in the American eneltropics (Ed. S. Fernández-Baca) FAO, Santiago de Chile (1992): 47-98.
36. Pimentel D. "Animal production energy inputs and the environment International Course Livestock, Sustainable Development and Environment". Module II. Pasture and Forage Research Institute, Ministry of Agriculture, Havana, Cuba (2003): 79-88.
37. Preston TR and Leng RA. "Adjusting livestock production systems to available resources". CONDRIT, Cali, Colombia (1989): 245.
38. Reid RL. "The future role of ruminants". In: Physiology of Digestion and Metabolism in the Ruminant (Ed. A.T. Phillipson) Oriel

Press, Newcastle upon Tyne. UK (1970).

39. Reyes E. Experience in the formulation and execution of livestock development projects in Latin America. Livestock Policy Discussion FAO, Rome 5 (2001): 72.
40. Ruiz R. "Nutritional Biochemistry. Digestive Physiology and Intermediate Metabolism". ENSPES, Ministry of Higher Education, Havana, Cuba 2 (1984).
41. Ruiz R. Nutritional management of food resources in tropical regions for sustainable cattle production. Pasture and Forage Research Institute and PRODUCE-OAXACA Foundation. Oaxaca, Mexico (2002).
42. Ruiz R. "Strategies for the sustainable development of cattle production in the tropics". Review of nutritional aspects of Livestock Science and Technology 11.1 (2017).
43. Ruiz R and Vázquez CM. "Consumption of tropical grasses. In: Los Pastosen Cuba". Utilization EDICA, Havana, Cuba 2 (1983).
44. Ruiz R., et al. Outstanding characteristics of milk production in Cuba Caratéristiques de la filierelaitiere. Atelier sur les perspectives de development de la production laitiereen region chaude. (L. Letenneur and J.F. Renard, editors). Exposé des participants. CIRADEMVT, Montpellier, France (1999): 19-24.
45. Ruiz R., et al. "Milk production with cows on Bermudagrass crossed No. 1 (Cynodondactylon Pers). II. Grass structure and productive potential". Cuban Journal Agricultural Sciences 15 (1981): 129.
46. Ruiz R and Menchaca M. "Mathematical models of voluntary consumption in ruminants". 2. Principles and method to estimate the potential dry matter intake of tropical pastures and forages. Cuban Magazine Agricultural Sciences 24 (1990): 51.
47. Ruiz R., et al. "Sustainable Tropical Bovine Production. Conferences - Postgraduate Course". IIPF, Havana, Cuba (2001).
48. Ruiz R and Alvarez A. Nutritional analysis of sustainable systems for cattle in the tropics Proceedings III International Symposium on Agroecological Livestock (SIGA 2007) Sancti Spiritus, Cuba (2007): 31
49. Ruiz R. "Meta-analysis on milk production per hectare based on pasture and forage in Cuba. II Workshop on Informatics and Biostatistics applied to Agricultural Sciences. Applications of Mathematical Statistics in Research, Innovation and Extension. IB-40. III Congress of Tropical Animal Production. Havana Cuba (2010): 333-334.
50. Ruiz R. "Milk production based on tropical pastures and forages. Review". Livestock Science and Technology 5.1 (2011): 1-21.
51. Ruiz R. "Realidades y perspectivas del forraje de caña de azúcaren la alimentación del ganadovacuno". Reseña. Ciencia y TecnologíaGanadera 6.3 (2012): 123146.
52. Steinfeld A. The livestock revolution. A global veterinary mission. Veterinary. Parasitology 125 (2004): 19-41.
53. Stobbs TH. "The effect of plant structure on the intake of tropical pastures 1". Variation in the bite size of grazing cattle. Aust. J. Agric. Res 24 (1973): 809.
54. Stobbs TH. The effect of plant structure on the intake of tropical pastures 2. Differences in sward structure, nutritive value and bite size of animal grazing Setaria anceps and Chloris gayana at various stages of growth. Aust. J. Agric. Res (1973): 24-821.
55. Stobbs TH. "Factors limiting the nutritional value of grazed tropical pastures for beef and milk production". Trop. Grassld 9 (1975): 151.
56. Stobbs TH. "Milk production per cow and per hectare from tropical pastures". En: Seminario Internacional de Ganadería Tropical. FIRA, Acapulco, México (1976).
57. Stobbs TH. "Short-term effects of herbage allowance on milk production, milk composition and grazing time of cow grazing nitrogen-fertilized tropical grass pastures". Aust. J. Exp. Agric. Anim. Husb 17 (1977): 892137.
58. Thornton RF and Minson DJ. "The relationship between voluntary intake and mean apparent retention time in the rumen". Aust. J. agric. Res 23 (1972): 871.
59. Thornton RF and Minson DJ. "The relationship between mean apparent retention time in the rumen, voluntary intake and apparent digestibility of legumes and grass diets in sheep". Aust. J. agric. Res 24 (1973): 889.
60. Vicente-Chandler J. Meat and milk production from intensively managed tropical grasslands in Puerto Rico. Sem. Int. Ganadería Tropical. FIRA, Acapulco, México (1976): 221.
61. Vilela D. y Resende JC. Sistemas de produção de leiteemclima tropical Embrapa Gado de Leite, Juiz de Fora, MG, Brasil (2004): 23.

62. Vicente-Chandler J. "Meat and milk production from intensively managed tropical grasslands in Puerto Rico". Sem. Int. Ganadería Tropical. FIRA, Acapulco, México (1976): 221.
63. Voisin A. Productividad de la Hierba. Editorial Tecno S.A., Madrid, España (1963).
64. Voisin A. Dinámica de lospastos. Editorial Tecno S.A., Madrid, España (1963).
65. Voisin A. "Influencia del suelosobreel animal a través de la planta. Ciclo de conferencias". Imprenta de la Universidad de La Habana, Cuba (1964).
66. West J. "Effect of heat stress on production in dairy cattle". J. Dairy Sci 86 (2003): 2131-2144.

Volume 1 Issue 2 July 2022